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Waste use as substrate to yield guava seedlings

Utilização de resíduos para produção de mudas de goiabeira

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Abstract

The guava tree (*Psidium guajava* L.), considered a rustic plant, can be found growing naturally in low-fertility soils. However, when commercially cultivated it needs considerable amounts of fertilizers and soil correctives to attain good yields. These special measures for cultivation start with choice of a suitable substrate to grow good-quality seedlings, allowing them to reach their full productive potential. The aim of this work was to study the effect of different substrates (S_1 – soil, S_2 – vermiculite+soil+fine sand, S_3 – cattle manure+soil+fine sand, S_4 – commercial substrate+soil+fine sand, S_5 – urban compost+soil+fine sand, S_6 – sewage sludge+soil+fine sand, S_7 – earthworm compost+soil+fine sand, S_8 – chopped sugarcane bagasse+soil+fine sand, and S_9 – sugarcane filter cake+soil+fine sand) in completely randomized design with four replicates on the development and nutritional state of guava seedlings. The result showed that the best substrates were vermiculite+soil+fine sand; earthworm compost+soil+fine sand; sugarcane bagasse+soil+fine sand, and filter cake+soil+fine sand. The use of sewage sludge and urban trash compost should be further studied for the composition of substrates.

Key words: *Psidium guajava*, nutritional state, compost mixture, seedling quality, growth

Resumo

A goiabeira, considerada uma planta rústica, pode ser encontrada vegetando em estado nativo em solos de baixa fertilidade, porém, quando cultivada comercialmente necessita de quantidade considerável de fertilizante e corretivo para obter boa produtividade. A preocupação no cultivo começa já na fase inicial de desenvolvimento com a escolha de um substrato adequado na formação de mudas de qualidade, permitindo que as mesmas expressem todo seu potencial produtivo. O objetivo desse trabalho foi verificar o efeito de diferentes substratos (S_1 – terra, S_2 – terra+areia fina+vermiculita, S_3 – terra+areia fina+esterco bovino, S_4 – terra+areia fina+substrato comercial, S_5 – terra+areia fina+substrato de lixo urbano, S_6 – terra+areia fina+lodo de esgoto, S_7 – terra+areia fina+húmus de minhoca, S_8 – terra+areia fina+bagaço de cana e S_9 – terra+areia fina+torta de filtro) em delineamento inteiramente casualizado com quatro repetições no desenvolvimento e estado nutricional de mudas de goiabeira. Os melhores substratos para formação de mudas foram obtidos com vermiculita+terra+areia fina; húmus de minhoca+terra+areia fina; bagaço de cana+terra+areia fina e torta de filtro+terra+areia fina. A utilização de lodo de esgoto e composto de lixo urbano deve ser mais bem avaliada para a composição de substratos.

Palavras-chave: *Psidium guajava*, estado nutricional, mistura de composto, qualidade das mudas, crescimento

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Introduction

The guava tree belongs to Myrtaceae family and is native to the tropical Americas. It has excellent characteristics for a commercial crop (NATALE et al., 1996; MANICA et al., 2001). The guava fruit is noticed not only for its attractive taste and aroma, but also for its high nutritional value. It currently is the fourth leading tropical fruit grown in Brazil and the country is the world's largest exporter by value and volume (ZIETEMAN; ROBERT, 2007).

The establishment of a productive orchards starts with the yield of healthy and vigorous seedlings, by growing them in an adequate substrate that provides for their nutritional requirements. The substrate composition directly affects the seedling yield and the development of young trees (PRADO et al., 2003). In general, the greatest gains in seedling yield have been obtained with the use of substrates made of plant remains or organic composts.

Besides being readily available at low cost, the substrate must be free of pathogens and have adequate characteristics such as good water retention, aeration and allow easy root formation, adequate texture and stability over a long period of time, especially for plants that require a long developmental period in the nursery (FERNANDES; CORÁ; BRAZ, 2006). The use of industrial wastes such as sugarcane bagasse and filter cake from sugar and alcohol industries to grow guava seedlings is becoming a common practice (CARDOSO; BENEDINI; PENNA, 1998). The use of sewage sludge is also a possibility, but careful analysis is necessary regarding the concentration of heavy metals to enable fruit production without harmful effects both on the environment and human health (MATTIAZZO-PREZZOTO, 1992).

In formulating and managing substrates, consideration must be given to their suitable chemical attributes, by monitoring the pH, cation exchange capacity (CEC) and salinity (SODRÉ et al., 2005). The pH range considered ideal varies according to the crop, the chosen substrate and the environmental conditions. The salinity can be estimated by measuring the concentration of ionized salts according to the electrical conductivity (EC) in solution (CAVINS et al., 2000). There are several commercial substrates available for yielding fruit tree seedlings, but few are recommended for growing guava seedlings. Therefore, the aim of this study was to evaluate the effect of different substrate components on the growth and nutritional state of guava seedlings.

Material and Methods

The experiment was carried out in a greenhouse environment at the Center for Nuclear Energy in Agriculture, University of São Paulo (CENA/USP), located in the municipality of Piracicaba (22º42'30" LS and 47º38'00" LW), São Paulo State, Brazil.

The experimental design was completely randomized with nine substrate treatments and four replicates. The treatments were made up of different ratios of components as shown in Table 1. These components were: soil containing 60% clay (dystrophic Red Alfisol), vermiculite [$(MgFe,Al)_3(Al,Si)_4O_{10}(OH)_2.4H_2O$], decomposed cattle manure, Plantmax® (commercial compost), urban compost, sewage sludge (dried solid), earthworm compost, chopped sugarcane bagasse, sugarcane filter cake and fine sand (125 – 250 μm). In each treatment, equivalent 1.0 t ha^{-1} of lime was applied.

The substrates were homogenized according to the ratios shown in Table 1 and allocated in 3.0 L polypropylene pots. The substrates were incubated for 30 days to allow stabilization of the aerobic fermentation process. After incubation, samples of each substrate were analyzed to determine the chemical attributes [(pH in $CaCl_2$ 0.01 mol L^{-1}, soil organic matter (SOM), available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), exchangeable acidity (H+Al) and available copper (Cu), iron (Fe), manganese (Mn) and zinc

(Zn)], according to Raij et al. (2001). As well as the electrical conductivity (EC) in a mixture substrate:water (1:1.5, v:v) (SONNEVELD, ENDE, DIJK, 1974). The results are shown in Table 2.

Table 1. Composition of substrates.

Treatments	Composition of substrates
S_1	Soil(1) (100%)
S_2	Soil (56%) + Fine sand (11%) + Vermiculite (33%)
S_3	Soil (56%) + Fine sand (11%) + Cattle manure(2) (33%)
S_4	Soil (56%) + Fine sand (11%) + Commercial substrate(3) (33%)
S_5	Soil (56%) + Fine sand (11%) + Urban compost(4) (33%)
S_6	Soil (56%) + Fine sand (11%) + Sewage sludge(4) (33%)
S_7	Soil (56%) + Fine sand (11%) + Earthworm compost (33%)
S_8	Soil (56%) + Fine sand (11%) + Chopped sugarcane bagasse (33%)
S_9	Soil (56%) + Fine sand (11%) + Sugarcane filter cake (33%)

(1)Dystrophic Red Alfisol; (2)Decomposed manure; (3)Plantmax®; (4)Local sewage treatment – ETE (Estação de tratamento de esgoto), Piracicaba county, São Paulo State, Brazil.
Source: Elaboration of the authors.

Guava seedlings of ‘Paluma’ cultivar from seeds were transferred to the pots containing the different substrates. The plants were watered daily with deionized water to maintain the moisture around 70% of the total pore volume (TPV) (CASSEL; NIELSEN, 1986). The substrates were fertilized by applying 163.6 mg kg^{-1} of nitrogen - N (urea – 44% N), 233.0 mg kg^{-1} of P (triple superphosphate – 40% P_2O_5) and 133.3 mg kg^{-1} of K (potassium chloride – 60% K_2O). The N was split in three amendments: 44.4 mg kg^{-1} during the incubation period (no seedlings), 66.7 mg kg^{-1} at the time of transplanting and 52.5 mg kg^{-1} 40 days after transplanting (DAT).

The plant height (H) was measured at 60, 90, and 120 days while the leaf area (LA) of the fourth leaf, stem diameter (SD) at 10.0 cm from the soil and the dry weight yield of the stems (SDWY), leaves (LDWY), roots (RDWY) and dry weight of the whole plant or total dry weight (TDWY) were measured at 120 (DAT). At the same time, the third pair of newly mature leaves and petioles was harvested (NATALE et al., 1994), and the material was washed in distilled water, detergent solution (0.1%), hydrochloric acid solution (HCl, 0.3%) and finally deionized water to remove the contaminants. The leaves and petioles were put in marked paper bags and placed in a convection oven at a temperature of, approximately, 65 °C for 72 hours to obtain the dry weight.

The dried material was then ground in a Wiley mill and then was sifted through a 1.0 mm mesh sieve for subsequent determination of the macro [N, P, K, Ca, Mg and sulfur (S)] and micronutrient [boron (B), Cu, Fe, Mn, and Zn)] contents, according to the methods described by Malavolta, Vitti and Oliveira (1997). At the end of the experimental period (120 DAT), after removing the plants, the pH_{CaCl2} of each substrate was measured again.

The H, DWYS, DWYL, DWYR, DWY (stem, leaves, roots and total), LA, and SD values, as well as the nutrient contents of the substrates and plants were subjected to analysis of variance (ANOVA), F-test and means compared by the Tukey’s test at 5% probability (PIMENTEL GOMES; GARCIA, 2002).

Table 2. Chemical properties of nine substrates[1].

Treatments	$pH_{CaCl2)}$		EC - PH	P	SOM	Ca	Mg	K	H+Al	CEC	V	Cu	Fe	Mn	Zn
	PI	PH	dS m^{-1}	mg dm^{-3}	g kg^{-1}	------------------- mmol$_c$ kg^{-1}					-- % --	-------------- mg dm^{-3}			
S_1	5.8	5.0	0.43	12.9	33.8	54.1	21.4	2.0	86.5	164.0	47.3	9.7	75.8	209.0	5.8
S_2	5.7	5.1	0.40	12.9	19.7	34.8	27.5	1.6	88.6	152.5	41.9	4.9	46.8	76.0	2.9
S_3	7.2	7.0	1.65	622.4	38.1	110.0	40.8	30.1	76.5	247.4	73.1	18.0	28.3	72.5	12.5
S_4	5.4	5.1	1.84	155.5	49.9	79.0	34.0	5.2	87.3	205.5	57.5	5.8	67.0	134.0	5.5
S_5	7.3	7.3	1.72	71.85	28.2	107.8	21.8	10.5	72.7	212.8	65.8	12.1	66.9	78.5	14.7
S_6	4.8	4.8	1.58	776.1	36.7	137.0	24.6	3.8	65.1	230.5	71.8	6.6	41.7	69.0	4.2
S_7	6.7	6.4	0.93	420.8	43.7	107.7	35.6	3.5	69.2	216.0	68.0	11.0	50.4	51.0	9.6
S_8	6.3	5.7	0.37	17.1	35.3	30.8	11.7	3.4	85.2	131.1	35.0	5.5	50.7	100.5	3.2
S_9	5.9	6.5	1.46	31.8	29.6	77.3	18.6	1.7	76.9	174.5	55.9	7.7	123.1	159.0	25.5
Mean	6.1	5.9	1.15	235.7	35.0	82.1	26.2	6.9	78.7	192.7	57.4	9.0	61.2	105.5	9.3

[1] S_1 (100% soil); S_2 (Σ 56% soil, 11% fine sand, 33% vermiculite); S_3 (Σ 56% soil, 11% fine sand, 33% cattle manure); S_4 (Σ 56% soil, 11% fine sand, 33% commercial substrate – Plantmax®); S_5 (Σ 56% soil, 11% fine sand, 33% urban substrate); S_6 (Σ 56% soil, 11% fine sand, 33% sewage sludge); S_7 (Σ 56% soil, 11% fine sand, 33% earthworm substrate); S_8 (Σ 56% soil, 11% fine sand, 33% Chopped sugarcane bagasse); S_9 (Σ 56% soil, 11% fine sand, 33% sugarcane filter cake); EC – electrical conductivity, PI – post-incubation; PH – post-harvest, SOM – soil organic matter; CEC – Cation Exchange Capacity; V – base saturation. Extractants: P – resin, K, Mg and Ca; Cu, Fe, Mn and Zn – DTPA-TEA, H+Al – Buffer SMP, CEC – Σ Ca, Mg, K, and H+Al; V – [(Σ K, Ca, Mg)/CEC]×100.

Source: Elaboration of the authors.

Results and Discussion

The H, LA, SD and SDWY, LDWY, RDWY and TDWY showed significant differences due to the substrates (Tables 3 and 4). In all three evaluations, substrate S_8 (sugarcane bagasse) yielded the greatest increase in H, SDWY LDWY, RDWY and TDWY, except at 120 days when plant height grown in it did not differ significantly from those in either S_2, S_3 or S_7 (Table 3). According to Cerri et al. (1988), although bagasse is chemically poor, its presence in substrates can enhance balance, aeration and plant nutrient uptake, since compacted substrates negatively affect plant growth, as also demonstrated by Arruda et al. (2007). Corroborating the results reported by Fernandes, Corá e Braz (2006), the presence of bagasse fibers in treatment S_8 enabled better root development by leading to suitable substrate density, aeration and water retention, characteristics that allow better root development. This fact was also observed by Zietemann and Roberto (2007) with coconut husk fiber and by Schiavo and Martins (2002) for filter cake and sugarcane bagasse.

Table 3. Plant height (H) of guava seedling grown in different substrates (1, 2) for 120 days.

Treatments	H			Δ
	60 days	90 days	120 days	
	cm			%
S_1	16.0 ab	29.7 bcd	55.0 cd	243.8
S_2	17.2 b	33.4 bc	72.7 abc	322.7
S_3	13.2 cd	26.6 de	64.5 abc	388.6
S_4	13.3 cd	27.0 cde	58.7 bcd	341.3
S_5	10.4 d	21.1 e	41.5 d	299.0
S_6	9.9 d	13.9 f	22.5 e	127.3
S_7	16.4 bc	33.5 bc	76.7 ab	367.7
S_8	21.6 a	42.1 a	82.2 a	280.6
S_9	15.8 bc	33.9 b	75.2 ab	375.9
Mean	14.9	29.0	61.0	3052
CV (%)	10.34	9.19	12.41	26.80
SMD	3.8	6.6	18.39	

(1) S_1 (100% soil); S_2 (Σ 56% soil, 11% fine sand, 33% vermiculite); S_3 (Σ 56% soil, 11% fine sand, 33% cattle manure); S_4 (Σ 56% soil, 11% fine sand, 33% commercial substrate – Plantmax®); S_5 (Σ 56% soil, 11% fine sand, 33% urban compost); S_6 (Σ 56% soil, 11% fine sand, 33% sewage sludge); S_7 (Σ 56% soil, 11% fine sand, 33% earthworm compost); S_8 (Σ 56% soil, 11% fine sand, 33% Chopped sugarcane bagasse); S_9 (Σ 56% soil, 11% fine sand, 33% sugarcane filter cake). Δ – Increase in plant growth days to 120 days; CV – coefficient of variation; SMD – Significant mean difference. (2) Averages with same letters in each column are not different by Tukey´s test with 5% of probability.
Source: Elaboration of the authors.

With respect to height, the presence of cattle manure in substrate S_3 caused the greatest increase in the guava seedlings growth at 120 days. The progressive mineralization of the organic matter (OM), with increased availability of nutrients to the plants, may have positively influenced these results. In contrast, the seedlings grown in substrates S_5 and S_6 presented the smallest SD, only 53% and 25%, respectively, of the values obtained with S_8 (Table 3). The urban compost (S_5), even though it is made up of SOM with adequate concentrations of the essential nutrients for plant development [P (71.9 mg kg^{-1}), Ca (107.8 $mmol_c$ kg^{-1}) and Mg (21.8 $mmol_c$ kg^{-1})], it also contains high concentrations of potentially toxic elements, such as lead (Pb) and cadmium (Cd) (GOMES et al., 2007), resulting in inadequate development of the guava seedlings. According to Malavolta (2006), any nutrient, whether or not essential, in excessive quantities can become toxic to plants and induce symptoms of deficiency of other nutrients by means of the inhibition effect. Fachini, Galbiatti and Pavani (2004) observed toxicity in citrus seedlings characterized as a negative regression caused by increasing doses of urban compost on seedling height and total dry weight.

The variation of pH ($CaCl_2$) of soil between the post-incubation and post-harvest presented distinct responses among the substrates (Table 2). The presence of filter cake, which is rich in carbonates, in substrate S_9 caused an increase in pH after seedling growth , while pH values declined in other substrates , remaining in the range of 5.8 to 6.8, considered adequate, in substrates S_7 and S_9 after 120 days (RAIJ et al., 1997)

The change in the substrate pH is related to several factors, among them the initial components used to as substrate, liming before transplanting the seedlings, the use of nitrogen fertilizer, root respiration and the plant species (CAVINS et al., 2000). Besides the availability of micronutrients is related to the soil acidity, since pH values lower than 5.8 can increase the availability of certain metal micronutrients, causing symptoms of toxicity in plants (CAVINS et al., 2000; MALAVOLTA, 2006), while pH values higher than 6.8 can cause the opposite effect, leading to copper (Cu), iron (Fe), manganese (Mn), nickel (Ni) and zinc (Zn) deficiency, as well as increased availability of chlorine (Cl) and molybdenum (Mo) (MARSCHNER, 1995; MALAVOLTA, 2006).

After the incubation period, only substrates S_1, S_2 and S_8 showed electrical conductivity (EC) within the range of 0.36 to 0.65 dS m^{-1}, indicated by Cavins et al. (2000) as adequate, while the EC was above 0.66 dS m^{-1} for the other substrates, a range considered to be due to high concentration of salts in the substrate (Table 2). According to these authors, measuring the EC in the solution of substrates allows to quantify total salts, which is an important factor for the ion balance in the solution, and consequently maintenance of the plant nutritional state. Substrates S_4 (Plantmax®) and S_5 (urban compost) showed the highest EC values (Table 2), on average 397% and 365% higher than substrate S_8, which led to the highest H and DMY values and (Tables 3 and 4). Besides the substrate composition, the use N (urea) and K (potassium chloride) fertilizers as side dressing probably increased these values.

The leaf N, P, Ca, Mg, S, B, Cu, Fe, Mn and Zn contents differed significantly according to the substrate used (Table 5). Substrates S_6 and S_9 led to the highest concentrations of N in the guava seedling leaves (34.3 and 32.3 g kg^{-1}, respectively). Despite the statistically significant differences observed among the treatments, all the nutrient concentrations were within the ranges considered adequate for guava trees (SALVADOR; MOREIRA; MURAOKA, 1998; NATALE et al., 2002a). With respect to P, even with the highest concentration available in the soil (Table 2), the lowest leaf contents were observed in plants grown in S_6 (sewage sludge). In this case, the small quantity of roots observed (Table 4) probably had a negative effect on the uptake of this nutrient. Besides, the B, Cu and Zn leaf contents (Table 5) were higher than in plants from other treatments, i.e., besides the process of uptake by mass flow that maintains a continuous nutrient supply, these nutrients influence the uptake of P by interionic inhibition through the formation of insoluble compounds (P-Mn) or negative P-Zn interaction (MARSCHNER, 1995; MALAVOLTA, 2006). Based on the range of 1.5 to 1.9 g kg^{-1} of P indicated by Natale et al. (1996) as adequate for guava, only plants grown in substrate S_6 were deficient in P (Table 5).

Table 4. Dry weight yield (DWY) of stem, leaves, roots and total, foliar area (FA) and diameter of stem (DS) in guava seedling cultivated in substrates different[1, 2].

Treatments	Dry weight yield				FA	DS
	Stem	Leaves	Roots	Total		
	grams				--- cm^2 ---	--- mm ---
S_1	1.9 ef	4.1 cd	1.4 cd	7.4 de	46.8 de	3.5 d
S_2	3.7 bcd	5.1 bc	3.0 ab	11.7 bc	68.4 bcd	4.8 bc
S_3	3.0 cde	5.7 bc	2.3 bc	11.0 bcd	81.6 ab	5.0 b
S_4	2.8 cde	4.4 c	1.6 c	8.9 cd	64.6 bcd	4.5 bc
S_5	1.2 fg	2.1 de	1.2 cd	4.5 ef	31.6 e	3.2 d
S_6	0.2 g	0.5 e	0.1 d	0.8 f	7.4 f	1.5 e
S_7	4.5 b	7.2 ab	3.0 ab	14.6 ab	93.7 a	5.0 b
S_8	6.4 a	8.1 a	3.8 a	18.2 a	79.3 abc	6.0 a
S_9	4.0 bc	7.1 ab	3.2 ab	14.3 ab	81.6 ab	5.0 b
Mean	3.1	4.9	2.2	10.2	61.7	4.3
CV (%)	19.04	18.21	26.28	7.15	12.92	9.13
SMD	1.4	2.1	1.4	4.2	22.9	0.9

(1) S_1 (100% soil); S_2 (Σ 56% soil, 11% fine sand, 33% vermiculite); S_3 (Σ 56% soil, 11% fine sand, 33% cattle manure); S_4 (Σ 56% soil, 11% fine sand, 33% commercial substrate – Plantmax®); S_5 (Σ 56% soil, 11% fine sand, 33% urban substrate); S_6 (Σ 56% soil, 11% fine sand, 33% sewage sludge); S_7 (Σ 56% soil, 11% fine sand, 33% earthworm substrate); S_8 (Σ 56% soil, 11% fine sand, 33% Chopped sugarcane bagasse); S_9 (Σ 56% soil, 11% fine sand, 33% sugarcane filter cake). Δ – Increase in plant growth days to 120 days; CV – coefficient of variation; SMD – Significant mean difference. (2) Averages with same letters in each column are not different by Tukey´s test with 5% of probability.

Source: Elaboration of the authors.

For K, the most required and exported nutrient by the guava tree (NATALE et al., 1996), the leaf contents were above the range of 12.7 to 14.6 g kg^{-1} (Table 5) found by Salvador et al. (2003) in plants with similar ages and grown under the same conditions. Due to the side dressing with K, no significant differences were observed among the treatments. In the case of Ca, only treatments S_2, S_3 e S_8 were within the range of 7.7 to 9.6 g kg^{-1} found by Salvador et al. (2003), while plants from other treatments presented higher leaf contents (Table 5). The plants grown in the substrate that contained sewage sludge (S_6), which had the highest content of exchangeable Ca (Table 2), presented significantly higher concentrations of this nutrient being up to 70% above the average of the other treatments. Despite having a significant variation among the treatments, the Mg leaf contents of were all above the level indicated as optimal by Salvador et al. (2003) for ‘Paluma’ cultivar at nursery stage grown under the same conditions.

Table 5. Macronutrients (N, P, K, Ca, Mg, and S) and micronutrients (B, Cu, Fe, Mn, and Zn) leaf contents from the third pair of newly mature leaves and petioles in guava seedling at 120 days after transplantation [1, 2].

Treatments	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg^{-1}						mg kg^{-1}				
S_1	27.8 c	2.7 ab	34.9 a	11.4 b	4.5 cd	4.1 abcd	60.0 c	19.0 ab	106.0 b	1382.0 c	46.0 b
S_2	29.4 bc	2.4 ab	33.0 a	7.7 d	6.3 ab	3.9 ed	48.0 f	17.0 bc	109.0 b	850.0 d	39.0 c
S_3	29.1 bc	3.2 a	36.4 a	8.2d	4.5 cd	4.2 abc	60.0 c	12.0 d	103.0 b	136.0 ef	35.0 d
S_4	27.8 c	2.4 ab	31.0 a	11.9 b	6.8 a	4.3 abc	125.0 a	9.0 d	98.0 b	1788.0 b	38.0 c
S_5	28.3 c	2.3 ab	30.0 a	12.3 b	3.4 e	4.5 ab	58.0 cd	20.0 a	91.0 b	91.0 f	35.0 d
S_6	34.3 a	1.0 b	32.5 a	19.4 a	7.5 a	3.5 e	88.0 b	22.0 a	203.0 a	11434.0 a	518.0 a
S_7	27.2 c	2.5 ab	29.0 a	10.3 bc	4.7 cd	3.9 cd	58.0 cd	9.0 d	88.0 b	207.0 ef	29.0 e
S_8	28.1 c	2.6 ab	30.0 a	8.8 cd	3.8 ed	4.6 a	55.0 de	15.0 c	103.0 b	371.0 e	33.0 d
S_9	32.3 ab	1.7 ab	30.5 a	12.2 b	5.5 bc	4.3 abc	53.0 ef	9.0 d	101.0 b	78.0 f	27.0 e
Mean	29.4	2.3	31.9	11.4	5.2	4.1	67.0	15.0	111.0	1815.0	89.0
CV%	3.84	30.75	19.07	6.44	6.87	3.42	2.51	7.02	15.79	4.75	1.12
SMD	3.2	2.0	16.8	2.1	1.0	0.4	5.0	3.0	49.0	245.0	3.0

(1) S_1 (100% soil); S_2 (Σ 56% soil, 11% fine sand, 33% vermiculite); S_3 (Σ 56% soil, 11% fine sand, 33% cattle manure); S_4 (Σ 56% soil, 11% fine sand, 33% commercial compost – Plantmax®); S_5 (Σ 56% soil, 11% fine sand, 33% urban compost); S_6 (Σ 56% soil, 11% fine sand, 33% sewage sludge); S_7 (Σ 56% soil, 11% fine sand, 33% earthworm compost); S_8 (Σ 56% soil, 11% fine sand, 33% Chopped sugarcane bagasse); S_9 (Σ 56% soil, 11% fine sand, 33% filter cake). Δ – Increase in plant growth days to 120 days; CV – coefficient of variation; SMD – Significant mean difference. (2) Averages with same letters in each column are not different by Tukey´s test with 5% of probability.
Source: Elaboration of the authors.

Leaf S contents also differed (Table 5). Treatment S_8 leading to the highest values and S_6 to the lowest. Magnesium leaf contents in plants from all treatments were above the range considered adequate by Salvador et al. (2003). For B, Cu, Fe, Mn and Zn (Table 5), in all cases there were significant differences depending on the substrate. Visual symptoms of Mn toxicity were observed during the experiment (SALVADOR; MOREIRA; MURAOKA, 1999) in plants from treatments S_1, S_2, S_4 and S_6, and it was confirmed by the high Mn leaf contents (Table 5). Plants from S_6 had the highest Mn and Zn leaf contents, reaching contents, respectively, 8 and 11 times higher than the contents observed in plants grown in S_1 (100% soil). Another factor that favored a high concentration of micronutrients in the seedlings was the low pH of some substrates (Table 2), causing an increase in micronutrient availability (MALAVOLTA, 2006, FAGERIA; MOREIRA, 2011). For Zn, the toxicity symptoms could have been minimized with the growth of the plant. Natale et al. (2002b) studying the response to Zn fertilization in guava seedlings, observed that the uptake and accumulation of Zn in the shoots and roots had a quadratic effect, reaching toxic levels and thus diminishing the DWY.

Conclusions

Substrates containing vermiculite, sugarcane bagasse, filter cake and earthworm compost promoted better development of the guava seedlings.

The use of sewage sludge in the quantity employed in this experiment was contraindicated for composition of substrates to produce guava seedlings.

The vermiculite, sugarcane bagasse, sugarcane filter cake and earthworm compost promoted better accumulation of macronutrients (N, P, K, Ca, Mg and S) and micronutrients (B, Cu, Fe, Mn and Zn).

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